EVALUATION OF TECHNIQUES TO MEASURE THE BIOAVAILABILITY OF METALS IN SEDIMENTS

PROPOSED STUDY DESIGN

February 16, 1993

The main purpose of this study is to determine which method of chemical analysis best measures the bioavailable fraction of metals. This evaluation is important in order to evaluate metals contamination at sites and to develop more meaningful sediment quality criteria. The secondary purpose of this study is to assess the effect of sample manipulation on the bioavailability of metals.

1. Sediment will be sampled at ten to fifteen sites that are dominated by metals contamination. Potential sites in San Francisco Bay are Point Potrero, Central Ave. property in Richmond Harbor area, Selby Slag, Peyton Slough, Hunters Point, Guadalope Slough, Coyote Creek, Richmond Rod and Gun Club, embayment between Sierra and Oyster Points, Pacific Dry Dock and other boatyards. Sites outside of San Francisco Bay that are being considered are the PACHO Terminal in San Diego and a reference site in Monterey Bay. Several reference sites and areas low in metals (probably on a gradient out from a more contaminated site) will also be included.

2. Sediment will be sampled by two different methods. For the first method, composite sediment samples will be collected and homogenized. Whole sediment will be used for chemical measurements, the amphipod toxicity test using Eohaustorius and bioaccumulation measurements using Macoma balthica. Some of this sediment will be subsampled and squeezed for pore water. In the second method, several intact cores from the same site will be squeezed for pore water. These samples will be taken at the same depth as the whole sediment. Pore water from the different cores will be homogenized. This second method will be used to evaluate the effect of sample manipulation on pore water chemistry and toxicity. The bivalve larvae toxicity test and chemical measurements will be conducted on pore water sampled by both methods.

3. The concentration of metals in whole sediment will be measured using four techniques: 1) total digestion, 2) AVS SEM, 3) another weak acid leach method, and 4) total digestion of the grain size fraction <100 um. Concentrations of metals in pore water, sampled by both methods, will be measured using a total digestion. Pore water samples will have already been filtered during the squeezing process. In addition, a copper probe may also be used to measure the free ion of copper. Organic chemical analysis will also be conducted on whole sediment samples to be sure that toxic levels of organics are not present. Total organic carbon and grain size will be measured in the whole sediment. Dissolved organic carbon will be measured in pore water. Ammonia and hydrogen sulfide will be measured directly after sampling and in the toxicity tests.

4. To measure toxicity the 10 day amphipod test using Eohaustorius will be conducted on whole sediment. The bivalve larvae developmental test will be conducted on pore water collected by both methods. To measure bioaccumulation, Macoma balthica will be exposed to whole sediment in the laboratory for 28 days.

5. The concentrations of metals measured by the various methods will be correlated with toxicity and levels of bioaccumulation.

QUESTIONS

1. Should there be changes in the study design?

2. What should be the sampling depth? Should it be a constant depth in which case the concentrations of sulfides would vary greatly between sites and oxic and anoxic layers would be homogenized? Or, should the sample depth be limited to the depth above the sulfide rich layer?

3. Do you have any recommendations on sites?

4. Are there any chemical methods that should be included or deleted?

5. Should the intact core pore water be collected in an oxygen free environment? If so, what should be done about the probability of low dissolved oxygen in toxicity tests?

6. Are the tests to measure bioavailability (toxicity and bioaccumulation) adequate?

REFERENCE SITE STUDY

PROPOSED STUDY DESIGN

February 16, 1993

In the past, high levels of sediment toxicity (up to 100% mortality in amphipod tests and high levels of abnormality in the bivalve larvae tests) have been found in areas with few sources of contamination and low levels of contaminants. These areas have included Tomales Bay, Bolinas Lagoon and Drakes Estero. We feel that it is essential to determine the causes of toxicity in these areas in order to identify toxic hot spots based on sediment toxicity tests. In addition, we need to identify a fine grain reference with which to compare other sites when conducting sediment toxicity tests.

The purposes of this study are to : 1) identify a fine grain reference site in the San Francisco Bay area for sediment toxicity tests and 2) determine the causes of toxicity in areas that have few sources of contamination, low levels of contaminants and no known factor that may be causing toxicity.

1. Guidelines for conducting estuarine sediment TIEs will be developed for the amphipod test using Eohaustorius and the bivalve larvae development test.

2. Sediment samples from seven sites that meet the criteria of a fine grain reference site (fine grain sediment, low levels of contaminants and not near any known sources of contamination) will be collected on a quarterly basis. Sites will include two sites in Tomales Bay, one site from Drakes Estero, one site from Bolinas Lagoon and three sites in San Pablo Bay.

3. Sediment will be analyzed for metals, organics, TOC, grain size, ammonia and hydrogen sulfide. At least two toxicity tests, including the 10 day amphipod test using Eohaustorius and the bivalve larvae development test, will be performed on each sample. The bivalve larvae test will be performed on pore water.

4. Samples will be split with Susan Anderson for positive interference studies (under a contract with the Corp of Engineers). If a sediment sample is toxic and there is no apparent cause for the toxicity a TIE will be performed.

HYDRODYNAMIC STUDIES
OVERHEADS FROM PRESENTATION

Towards a Sediment Transport Model:

Compute hydrodynamics (TRIM2D)
(Assume independent from sedimentation processes)

Solve advection–diffusion equation for sediment concentration:

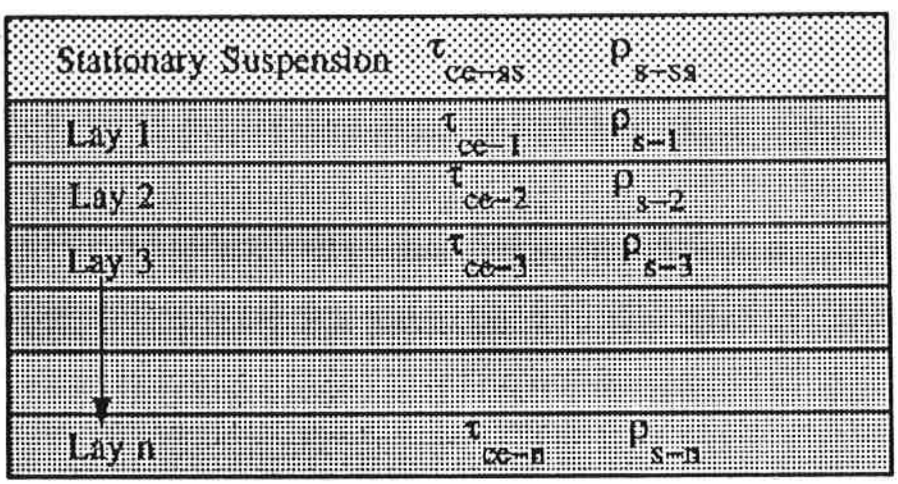
$$\frac{\partial(HC)}{\partial t} + u\frac{\partial(HC)}{\partial x} + v\frac{\partial(HC)}{\partial y} = \frac{\partial}{\partial x}\left(K_h\frac{\partial(HC)}{\partial x}\right) + \frac{\partial}{\partial y}\left(K_h\frac{\partial(HC)}{\partial y}\right) + S$$

where S = source/sink term for sediment

Model source/sink term based on empirical formulations for erosion and deposition

For cohesive sediments, bed structure and consolidation should also be modeled:

e.g.



) **Result:** What we get out is only as good as what we put in!

Cohesive Sediment Transport Equations

eposition

rone (1962):

$$\frac{dC}{dt} = \begin{cases} -\frac{2W_s}{H}C(1-\frac{\tau_b}{\tau_{cd}}) & \text{for } C < C_c \\ -\frac{2W_s}{HC_c^{4/3}}C^{5/3}(1-\frac{\tau_b}{\tau_{cd}}) & \text{for } C > C_c \end{cases}$$

SF Bay: $C_c = 300$ mg/l

put: * bottom shear stress, τ_b
* characteristic settling velocity, W_S
* suspended sediment concentration, C
* critical shear stress for deposition, τ_{cd}

utput: deposition rate (conc./time)

rosion

$$\frac{dC}{dt} = \frac{P}{H}\left[\frac{\tau_b}{\tau_{ce}} - 1\right]$$

iput: * bed shear stress, τ_b
* critical shear stress for erosion, τ_{ce}
* empirical erosion rate constant, P

utput: erosion rate (conc./time)

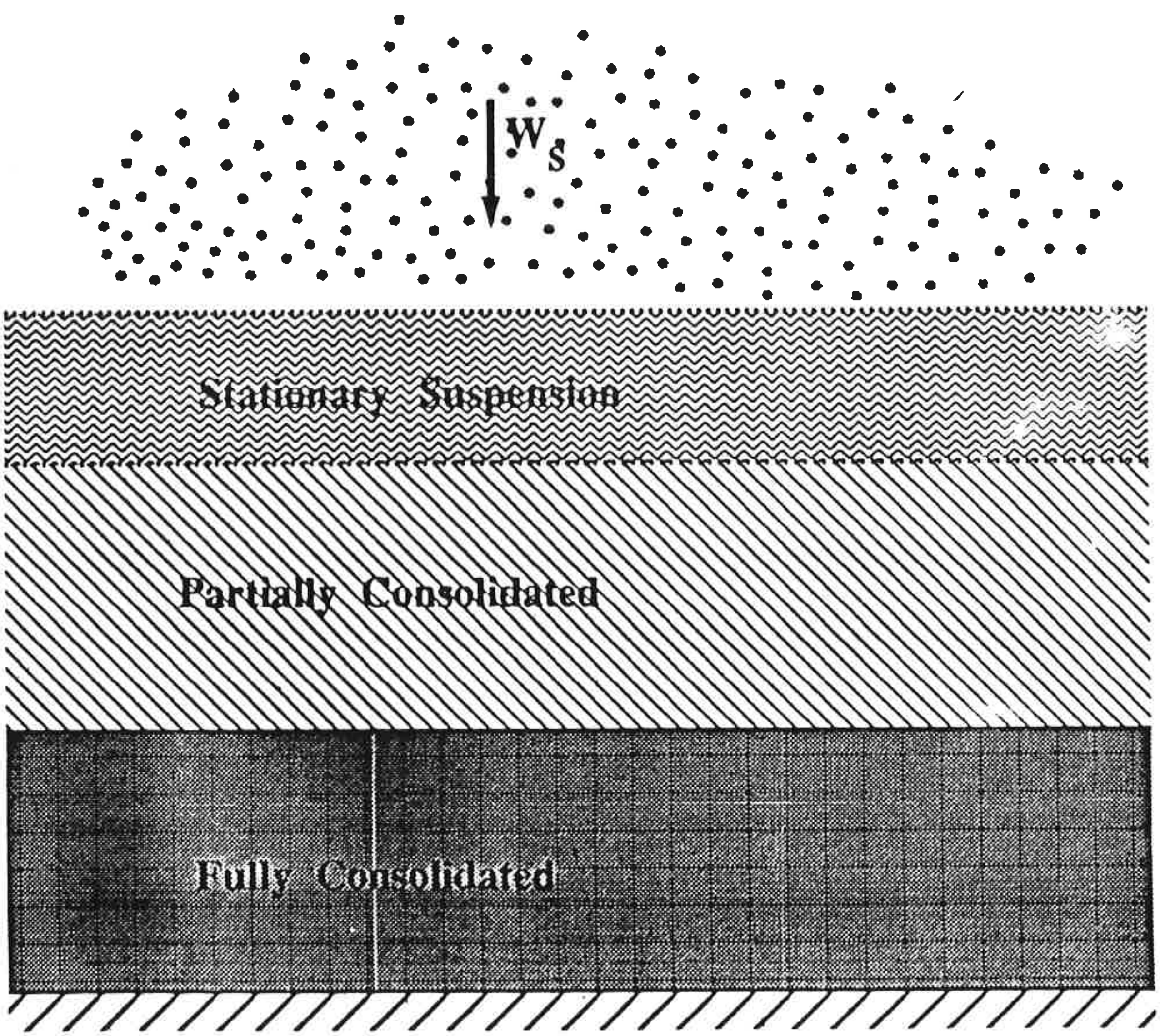
Cohesive Sediment "Complications"

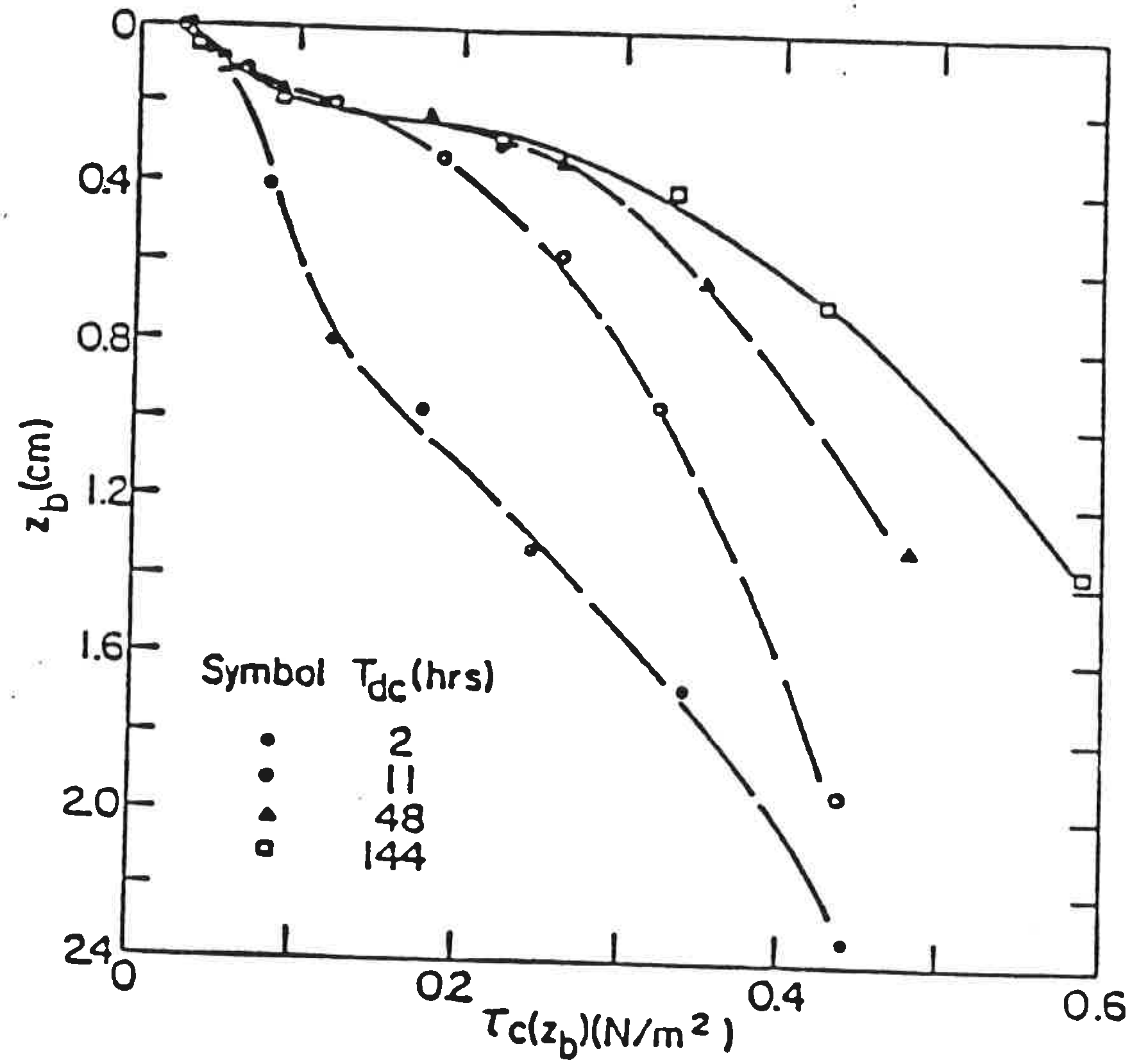
Flocculation = f(cohesiveness, particle collisions)

Three mechanisms of interparticle collisions:

1) **Brownian Motion**
2) **Differential Settling**
3) **Internal Shearing**

Consolidation





Variation of τ_c (z_b) with z_b for Various Consolidation Periods (after Dixit, 1982).

(Kaolinite in tap water)

Cohesionless Sediment Transport Equations

nput: * bottom shear stress, τ_b
* mean velocity, U
* sediment density, ρ_s
* characteristic grain size
* empirical parameters

)utput: "equilibrium" transport rate for cohesionless sediment (mass/time/unit width)

:xample:

$$q_{st} = 0.05\rho_s U^2 \left[\frac{d_{50}}{g}\left(\frac{\rho_s}{\rho} - 1\right)\right]^{1/2} \left[\frac{\tau_b}{(\rho_s - \rho) g d_{50}}\right]^{3/2}$$

Engelund and Hansen (1967)

'roblem: Formulations only apply to steady flows

Bottom Shear Stress

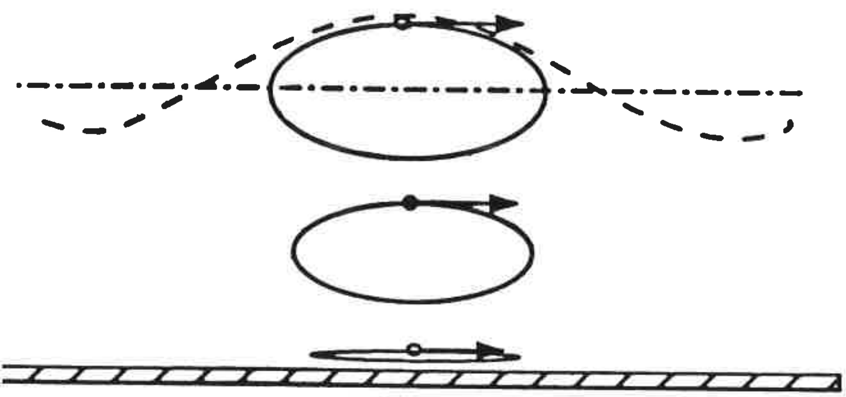
) TRIM: Manning–Chezy equation

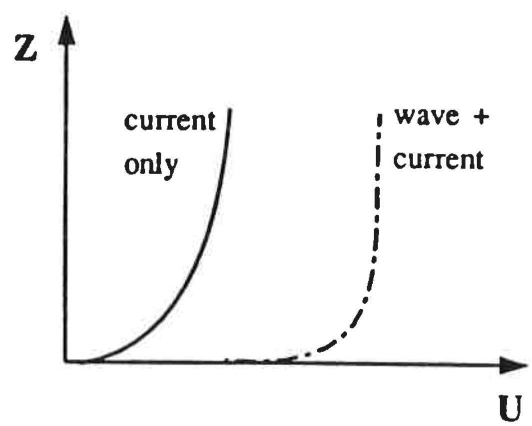
$$\tau_{bx} = \rho_0 \frac{g\sqrt{u^2 + v^2}\, u}{C_z^2}$$

$$C_z = \frac{H^{1/6}}{n}$$

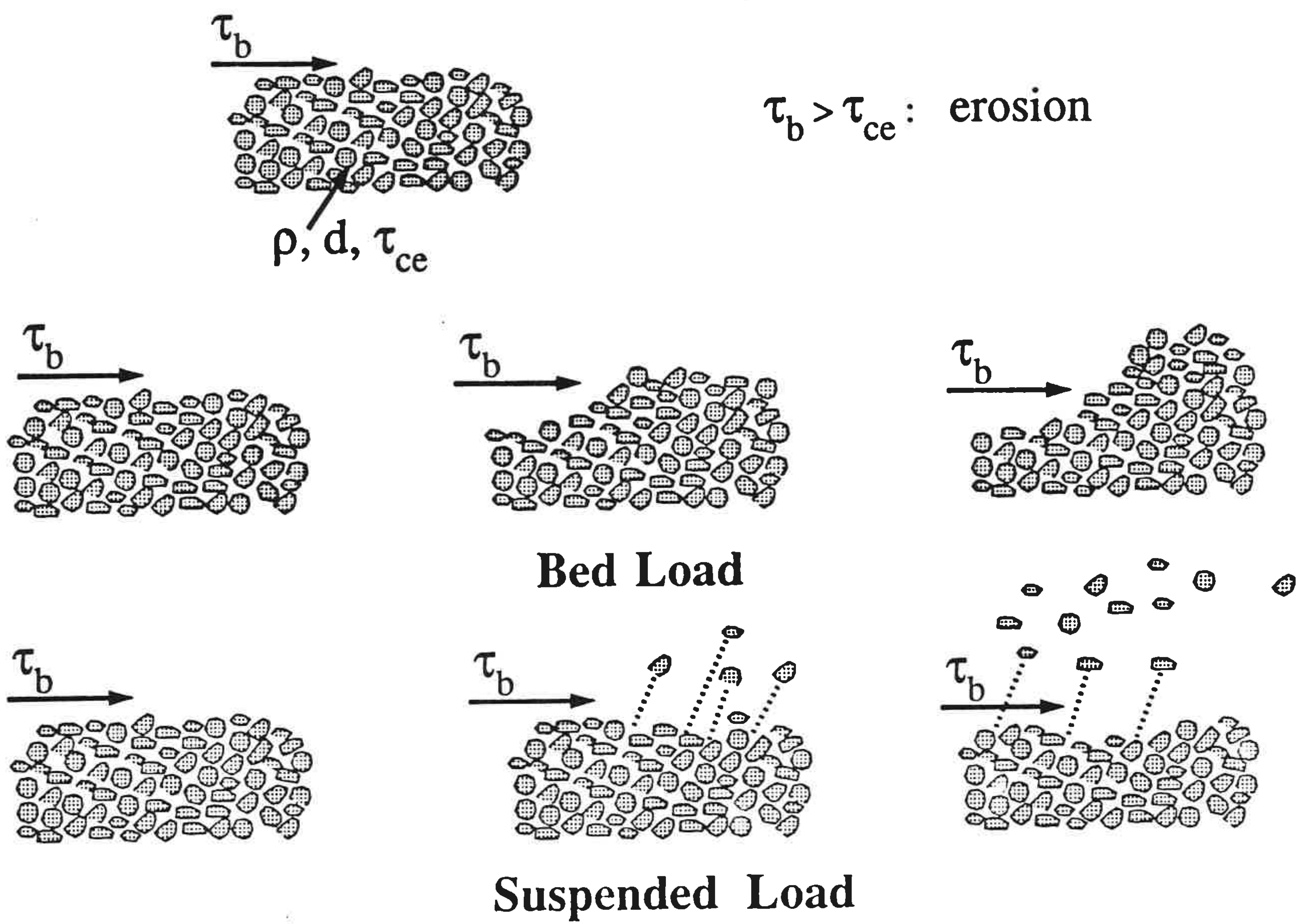
) Wave–current interaction: Madsen formulation

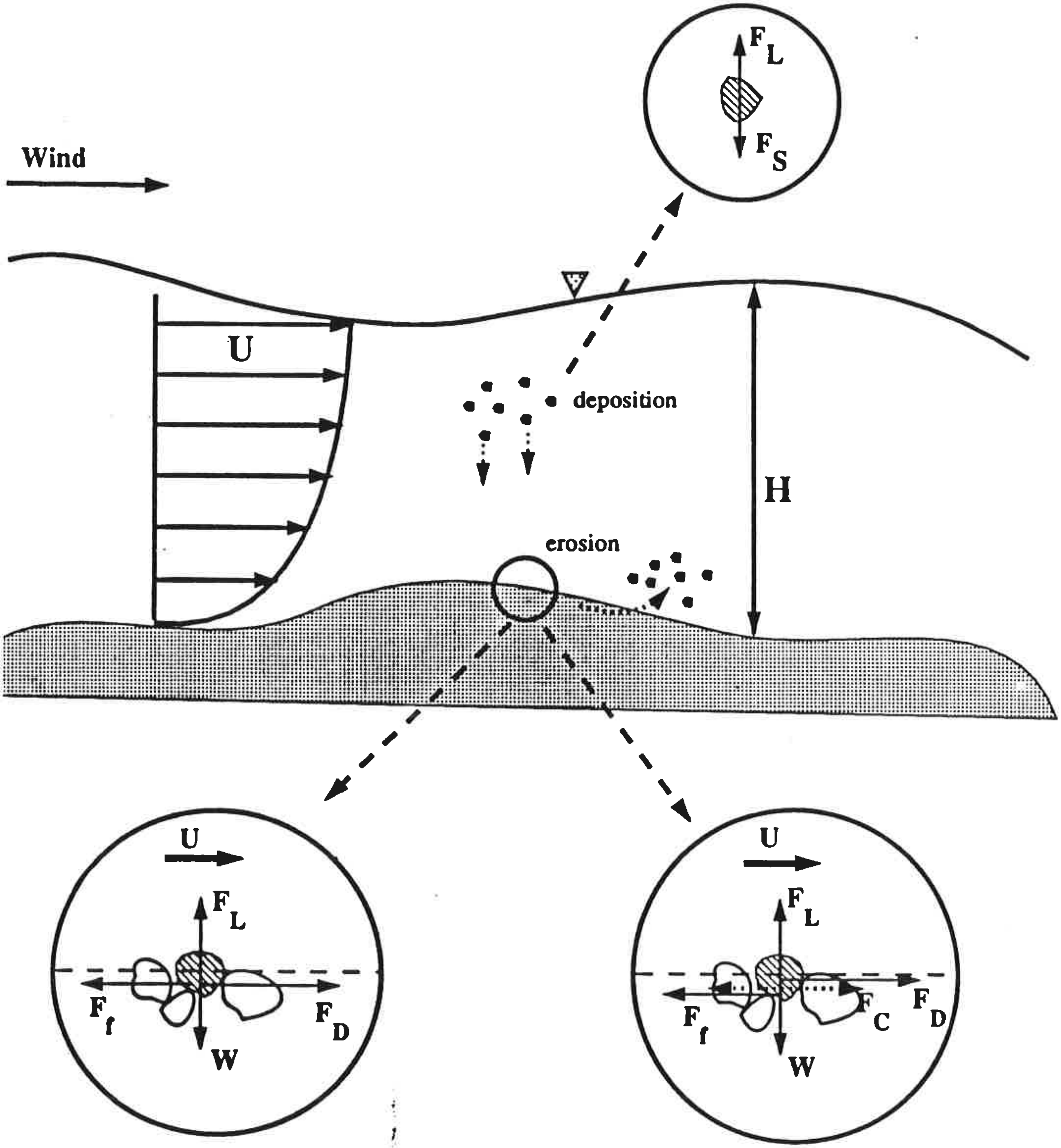
* Wave orbital motions increase bottom shear stress:





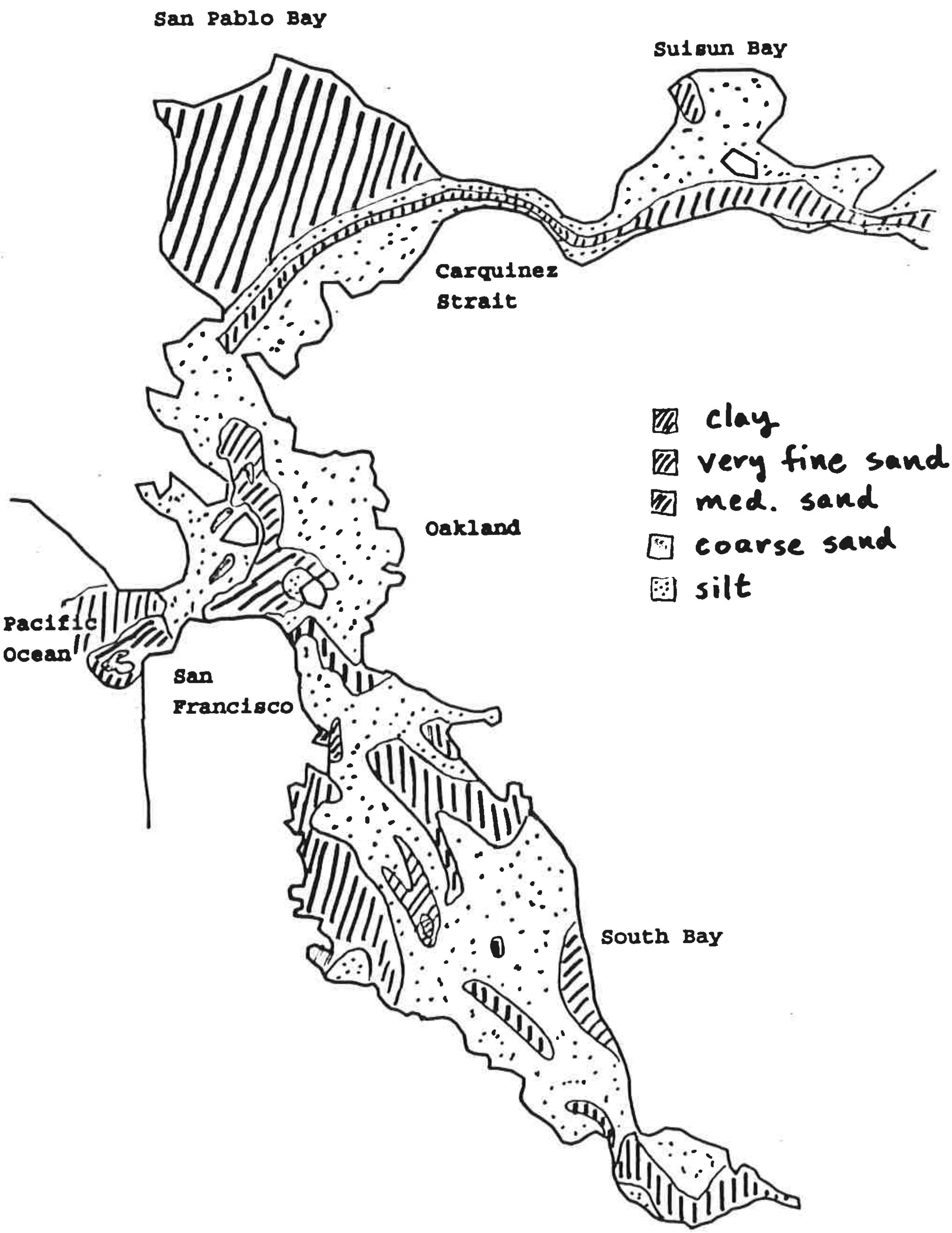
* effect of waves felt for H < λ/2
* $\tau_{c+w} = f\,(\tau_b$, bottom roughness, wave characteristics, angle between waves and current)


τ_b
ρ, d, τ_{ce}
$\tau_b > \tau_{ce}$:   erosion
τ_b
τ_b
τ_b
Bed Load
τ_b
τ_b
τ_b
Suspended Load



Cohesionless

Cohesive


San Pablo Bay
Suisun Bay
Carquinez
Strait
clay
very fine sand
med. sand
coarse sand
silt
Oakland
Pacific
Ocean
San
Francisco
South Bay

Folger (1972)

LETTER REPORTS

Donald F. Boesch, Ph.D.

1770 Baltimore-Annapolis Boulevard • Annapolis, Maryland 21401 (410) 757-7965

February 20, 1993

Mr. Thomas H. Wakeman
LTMS Project Manager
San Francisco District
Corps of Engineers
211 Main Street
San Francisco, CA 94105-1950

Dear Tom:

This letter report summarizes my observations and comments on the Long-Term Management Strategy technical studies which were presented or discussed at the February 19., 1993 meeting.

General Comments on the LTMS

First, the general progress of the LTMS efforts is encouraging. I was pleased to learn that the Management Committee has elected the "high risk" option, requiring collective balancing of environmental and economic interests and coordinated management of both regional navigation dependent on dredging and magnitude of long-term environmental consequences from dredging activities. This is an important commitment--and one that will place considerable demands on the quality and pertinence of scientific information and understanding. The selection of an ocean disposal site and issuance of the Environmental Impact Statement for formal site designation by the Environmental Protection Agency has also been a very important step toward development of a comprehensive plan for dredged material management and disposal.

With these important developments in mind and as I learn more about the issues surrounding current disposal practices, I have a general outline in my mind about what the Long-Term Management Strategy will probably look like as the needed consensus forms:

1. The designation and effective management of an ocean disposal site will provide opportunity for new project dredging which has previously been stymied, but will not provide a feasible alternative for maintenance dredging for all but the largest channel projects. The key scientific/technical issue confronting the management of this disposal site will be the development and implementation of a reliable environmental monitoring program and the coupling of this monitoring program with realistic dispersion models.

2. Continuing and potentially unresolvable concerns over in-bay disposal will, in the short run at least, rule out designation of other in-bay disposal sites (except for wetland creation and enhancement) and will place unrelenting pressure to reduce the volumes and restrict the quality and timing of dredged material disposal. The recent Public Notices 93-2 and 93-3 illustrate this trend. The key scientific/technical issues which will influence decisions

governing in-bay disposal will be a) where does the material ultimately go and does the material leaving the disposal site degrade habitat quality elsewhere; b) how sure are we that the dredged material disposed in the Bay is "non-toxic;" and c) does the suspended or resuspended material adversely affect important fishery species during critical life history stages or migration.

3. As limits to in-bay disposal continue, if not tighten, and the ocean disposal option remains infeasible for all but major projects and for contaminated sediments disapproved for ocean disposal, the need for upland disposal will grow. Around the key issues identified in number 2, above, will revolve alternatives between in-bay and upland disposal. Habitat enhancements and reuse options should be pursued and may help change the public mindset of dredged materials as necessarily a harmful "waste" and may effect some environmental improvements. These options are, however, unlikely to accommodate any significant proportion of dredged materials which cannot be disposed in the ocean or in the Bay. Beyond the attendant social, economic, political and legal issues which play a major role in upland disposal, key scientific issues will revolve around the effects of potential loss of the dredged material or its constituents to surface or ground waters and, in that vein, the effectiveness of confinement of dredged materials deemed contaminated.

If this prospective is realistic, it seems to me that at this stage in the process the LTMS ought to take a hard look at the degree to which the issues identified are being resolved by ongoing studies and make every effort to move such resolution--or at least a narrowing of uncertainties--along.

In-Bay Studies

Three questions were posed for the meeting which deal with: 1) potential consequences on fisheries, hydraulics, and water quality; 2) limits on diversions of existing volumes of dredged materials to ocean or upland disposal without causing erosion of Central Bay mud flats and marshes; and 3) what additional studies are necessary to determine best management practices for continued in-bay disposal. Pursuant to the third question, based on the line of reasoning developed in my prospective above. LTMS studies should be addressing: a) where the material ultimately goes and the degree to which this degrades habitat quality beyond the disposal site; b) confidence in determination of potential toxic effects; and c) the potential that suspended or resuspended dredged material adversely affects important fishery species during critical life history stages or migration. These issues are embodied in, but are a subset of, the issues addressed in the first question posed for the meeting. The adequacy with which they are being addressed is discussed below. With regard to the second question, I do not believe there is a convincing *prima facie* case that erosion of mud flats and marshes would result from disruption of the sediment budget by reduction of dredged material disposal in the Bay. Other factors affecting the sediment budget, in particular those that interfere with riverine sediment input (flow variations and upstream trapping) or changes in relative sealevel, are far more likely to affect littoral accretion and erosion, in my opinion. Of course, I am not an expert on this subject and the opinions of sedimentologists might be sought.

With regard to the adequacy of the LTMS studies to address the three issues I suggested will influence in-bay disposal, I continue to be concerned that not enough is being done to relate--either through direct assessment or exposure-effect models--the susceptibility of early developmental or migrating stages of important fishery species (issue *c*). Although we received a presentation on only one aspect of the hydrodynamic/sediment transport studies, it is not clear to me that these studies will adequately address issue *a*. The development of sediment transport models based on fundamental theoretical considerations (such as presented by Ellen McDonald), although scientifically worthy, are not likely to yield realistically predictive models. Also, I got the impression that the hydrodynamic/sediment transport efforts have a broad regional perspective and are not focused on the environs of the disposal sites, where the critical effects questions reside. It seems to me that a more empirical, geographically focused approach to modeling changes in hydraulics, sediment transport and deposition of fine sediments outside of the disposal sites would be more valuable. Finally, I believe the ongoing studies should be relatively successful in resolving issue *b* through assessment of the risk of toxic effects.

We were asked to provide comments on descriptions or scopes of work for several proposed studies. I offer the following:

Reference Site Study

This study addresses the vexing problem of unexplained mortalities of amphipods in presumably clean, reference sediments. Resolution of this problem and determination of reliable reference sites are of critical importance for insuring the reliability of the primary method for determining potential toxicity of dredged material. Not a lot of detail on the study design is included in the write-up. The use of *Eohaustorius* as opposed to *Ampelisca* or *Rhepoxinius* seems reasonable given its wide salinity tolerance. It is unclear why the sampling and testing need to be done quarterly. I would prefer more concerted effort during fewer time periods.

Bioaccumulation Study

The information need is important and the study approach seems reasonable. The focus on organics, and PAHs in particular, seems justified. I wonder whether similar organisms and sediment types will be found at all of these sites to allow good comparisons. To the greatest extent possible, the same species should be used for analysis of field specimens and for laboratory testing for a given site.

Evaluation of Techniques to Measure Bioavailability of Metals

I am less convinced about the need for or effectiveness of this study. I share the concern that there is little evidence that trace metals in sediments, particularly those that are reducing, are either taken up or cause serious biological effects in benthos. In addition, there are great difficulties in sampling or experimenting with sediments or pore waters that preserve the state in which the metals exist in nature. This study may be justified because of other RWQCB requirements, but would contribute little to the development of the LTMS.

Simplified Test for Predicting Surface Runoff Water Quality

As I indicated in my general comments, the contamination from runoff from upland disposal sites is an issue which will have to be resolved. The development of the test offers the prospect of predicting the effects of surface runoff on water quality at required test scales and within reasonable test periods. Experts at the Waterways Experiment Station have extensive experience in this area.

I hope these comments are helpful. Of course, if there are any questions about them which arise among LTMS participants, I would be happy to respond to them.

Sincerely yours,

Don

Donald F. Boesch

PTI
ENVIRONMENTAL SERVICES
375 SE 30th Place ■ Suite 250 ■ Bellevue, Washington 98007 (206) 643-9803 ■ FAX (206) 643-9827

13 March 1993

LTMS Management Committee
U.S. Army Corps of Engineers
Attn: Mr. Thomas Wakeman
211 Main Street
San Francisco, California 94105

Subject: Meeting Comments for February 19, 1993
Technical Review Panel for the Long-Term Management Strategy
PTI Project C421-01-01

Dear Mr. Wakeman:

This letter represents my comments on the presentations and written materials that were included in the Long Term Management Strategy (LTMS) Technical Review Panel (TRP) meeting held on February 19, 1993. Once again, it was a pleasure meeting with you and the other participants. In general, I found the presentations to be informative and provided a good overview of ongoing and planned in-bay activities.

In addition to my verbal comments presented at the meeting, I would like to submit written comments on the following technical items:

- Reference Site Study - Proposed Study Design
- Evaluation of Techniques to Measure the Bioavailability of Metals in Sediments - Proposed Study Design
- Bioaccumulation Study - Scope of Work
- Interim Sediment Screening Criteria and Testing Requirements for Wetland Creation and Upland Beneficial Reuse
- Second Quarterly Report: Summary of Literature Relevant to Sediment Transport in San Francisco Bay

REFERENCE SITE STUDY

This proposed study is designed to meet the following objectives: 1) identify fine-grained reference sites in the Bay area; and 2) to determine the causes of the relatively high sediment toxicities that have been observed in these areas. I suggest that the study be designed with a clear separation of the two objectives. For the first objective, the collection of sediments from only seven sites (some of which have previously displayed high toxicity) may be insufficient in scope. To meet this objective, samples should be collected from as many sites as possible to increase the probability of finding a suitable reference site with relatively low toxicity. I question the value of collecting samples on a quarterly basis. The investigators should consider a more comprehensive, synoptic effort at more than seven candidate sites. As designed, the study proposes that four of the candidate sites be located in Tomales Bay, Drakes Estero, and Bolinas Lagoon, areas that have previously been shown to be toxic to the test species. Is this sampling design for new sites within these water bodies, or is it a resampling of the previously tested sites?

For the second objective, the studies should be focused on a very limited number of sediment sites that cause high toxicity that does not seem to be associated with increased levels of sediment contaminants. These sites could be identified based on measured toxic responses and physical/chemical characteristics of the test sediments.

The objective of Task 1, to develop guidelines for conducting estuarine sediment TIEs, is not clear in the study proposal. Also, the proposal should indicate which sediment manipulations would be used in the TIEs and the presumed toxic constituents that would be addressed by each experimental manipulation. Based on this information, and on the physical/chemical measurements selected for study, the proposal should include an assessment of the potential to successfully identify the toxic factor(s). At present, it appears that the candidate factors would be limited to grain size, ammonia, and sulfide. Two questions should be addressed: 1) Do these variables represent the full range of potentially toxic factors?; and 2) Are there available TIE procedures that can be used to address each of the potential toxic factors?

BIOAVAILABILITY OF METALS IN SEDIMENTS

Although this proposal was not discussed in detail at the meeting, I have several comments on the design. The results of this study could be generally valuable in the assessment of metal toxicity and in the development of sediment quality criteria for metals. However, I recommend that the authors consider a more focused study with fewer design variables and study objectives.

Prior to finalizing the study design, the authors of this proposal should refer to a recent publication by Ankley et al. (Environmental Toxicology and Chemistry, Vol. 12, pp. 315-320, 1993) in which some similar analyses were conducted on freshwater sediments. The authors concluded that acid volatile sulfides (AVS) alone was not an adequate predictor of copper toxicity. Although they did not measure pore water toxicity directly, theoretical pore-water toxicity was a much better predictor of the toxicity of test sediments than AVS. The results of this study, and other work by EPA, should be carefully evaluated to determine whether AVS SEM warrants further research.

I believe the basic question that should be addressed in these studies is whether analysis of metals in whole sediment samples or pore water samples represents the best predictor of sediment toxicity. Analyses of AVS SEM or weak acid leaching may be additional candidate methods. Given the complexity of this problem (EPA has been studying it for several years), I suggest that you consider assessing sediment toxicity only. If metals bioaccumulation is to be addressed, it should be evaluated as part of the proposed field vs. laboratory study (see below) or in lieu of PAH in the bioaccumulation study.

The method of pore water extraction is not specified in the proposal, except to state that it will be "squeezed". The characteristics of pore water samples are highly dependent on the preparation method used. I believe that centrifugation would represent a better method of pore water extraction from the sediment samples. The proposal implies that a filter will be used in the extraction process. If so, the composition and pore size of the filter should be specified.

BIOACCUMULATION STUDY

As proposed, this research study may produce some potentially valuable information concerning the relationship between field measurements and laboratory-derived estimates of bioaccumulation levels. However, I question the relationship of this study to the overall LTMS objectives and the potential value to the program in relation to the presumed cost. Although I do not have cost information, it appears that costs would be relatively high given the apparent number of chemical analyses that would be required with appropriate replication.

I am also concerned about limiting the study to analyses of PAH. Although high PAH levels in sediments may be important in some parts of San Francisco Bay, I have generally found that metals and chlorinated hydrocarbons are of higher concern in most situations. It is also important to note that Bob Risebrough concluded in his January 2, 1993, correspondence to you that "...the PAHs are a non-problem in San Francisco Bay". Given Dr. Risebrough's expertise in this area and the rationale behind his conclusion, I believe that the plan to focus on PAH should be reconsidered.

If this study is funded and the focus is PAH, there should be a careful evaluation of the individual PAH analyzed. The analyte list presented under Task 3 is highly biased toward high molecular weight (MW) PAH. Therefore, the study would focus on PAH from combustion sources, with very little analyses of petroleum-related compounds. For example, anthracene is included in the analyte list, but other important low MW PAH such as phenanthrene, fluorene, and acenaphthylene are not specified. The high MW PAH dibenzo(a,h)anthracene is also omitted from the list.

With regard to Task 2, Item 3., it is very important to use the same test species in the field and laboratory analyses. Even closely-related species may display very different bioaccumulation levels for individual chemicals. The inclusion of different species as a study design factor could result in considerable uncertainty in the results (i.e., whether measured differences in bioaccumulation are the result of different species being used or are the result of laboratory vs. field effects). If the study is conducted as generally designed, it should be limited to sites where the designated bivalve and worm species are available. If these species are not available at one or more of the eight selected stations, alternative sites should be selected for which both species are available. Alternatively, a reduced suite of sites could be used for which both species are available.

INTERIM SEDIMENT SCREENING CRITERIA

At the previous TRP Meeting, I commented on the use of ERL and ERM values from Long and Morgan (1991) in the LTMS Program. The essence of my comments was that the data compilation and analysis procedures used to derive ERLs and ERMs have serious technical flaws and result in numbers that have little relationship to actual sediment toxicity thresholds. Since that meeting, I have received a document entitled *Interim Sediment and Testing Requirements for Wetland Creation and Upland Beneficial Reuse* that was prepared by the California Regional Water Quality Control Board, San Francisco Bay Region (December 1992). In this document, the ERLs and ERMs (or related values) were used to establish wetlands creation cover screening criteria. Although the interim testing document does not explicitly state that the sediment screening criteria will be used as part of LTMS, this use is implied based on the discussion of LTMS in the introduction of the report. When I again raised this issue at the recent TRP Meeting, I was somewhat encouraged upon hearing that Dr. Robert Engler and Karen Taberski shared some of my technical concerns on the regulatory use of these values. However, notwithstanding these concerns, it appears that the values were adopted as interim screening criteria because no other candidate numerical values were available.

I again express my concern regarding the use of ERL and ERM values, even as interim criteria. First, there is a danger that, once adopted on an interim basis, the values could be accepted as final criteria without the necessary critical scientific review. Moreover, I cannot accept the philosophy that seriously flawed numerical criteria should be adopted for regulatory use simply because of an absence of technically valid criteria. The absence of such "off-the-shelf" criteria indicates the need for development of scientifically valid screening criteria for San Francisco

Bay. On an interim basis, I recommend the use of direct, project-specific biological testing in lieu of chemical-specific numerical criteria.

I have included my specific comments on ERL and ERM values as Attachment A to this correspondence.

SEDIMENT TRANSPORT/HYDRODYNAMICS

Some of the information presented on this subject at the meeting was beyond my technical understanding. Although I am not an expert in this area, I find it difficult to see how a useful predictive tool can be developed within the remaining schedule for LTMS. Potential problems or complicating factors include:

- Complex and/or poorly understood hydrodynamics of the system
- High temporal and spatial variability of suspended solids levels
- Highly variable sediment types, especially cohesive types
- Uncertainties of the model equations
- Poor understanding of sediment resuspension and subsequent transport.

Given these uncertainties, and those expressed by Ellen McDonald at the TRP meeting, I question whether the resources allocated to this task will result in a valuable product by the end of the current program. I recommend that the Management Committee consider a reallocation of funds to more critical issues at this point in time. I believe that the consequences of in-bay disposal at dispersive and nondispersive sites can be better addressed by carefully evaluating candidate site characteristics (or by using an empirical model) and establishing a well-designed monitoring program to evaluate sediment transport following disposal actions.

Once again, I appreciate the opportunity to participate in the LTMS technical review process and look forward to future review meetings concerning other aspects of the program.

Very truly yours,

T. C. Ginn

Thomas C. Ginn, Ph.D.
Vice President

Attachment

ATTACHMENT A - REVIEW OF ERL/ERM APPROACH

Long and Morgan's (1990) approach represents a recent attempt by the National Oceanic and Atmospheric Administration (NOAA) to summarize available sediment effects data from throughout the country and develop estimates of ranges in chemical concentrations at which adverse biological effects would be expected to occur. NOAA's database included available sediment quality values that have been developed using the approaches such as AET, EqP, and spiked sediment bioassays, as well as data points for individual studies that were identified by the authors. The authors first separated the data sets that had measurements of one or more toxic chemicals in the sediment sample and resulted in an adverse effect (usually a significant toxic response in a bioassay). The data were then sorted by increasing concentrations of each toxic chemical, and two statistical values were determined:

- ER-L, the 10th-percentile concentration corresponding to the lower end of the range of concentrations where effects were measured
- ER-M, the 50th-percentile concentration corresponding to the median of the range of concentrations where effects were measured.

For each chemical, Long and Morgan (1990) also identified the level of confidence associated with the ER-L and ER-M values. The authors also caution that "No other more rigorous statistical procedures were used, since the consensus ER-L and ER-M values were intended only for use by NOAA as general guidance in evaluating the NS&T Program data." A summary table of ER-L and ER-M values and example data sets for individual chemicals (mercury, copper, and total DDT, and pyrene) are included as Appendix A to these comments.

Upon initial inspection, the database developed by Long and Morgan (1990) could appear as a logical starting point for the initial development of sediment screening criteria for San Francisco Bay. However, a more detailed evaluation of the database and the general approach demonstrates that the overall approach is seriously flawed and would not be appropriate for such purposes. Both the underlying database and the general approach to calculate ranking criteria are evaluated in the following sections.

Database Issues

The present database contains a considerable amount of information that would not be applicable to San Francisco Bay. Many of the data used to develop ER-L and ER-M values were based on studies conducted on freshwater organisms in other areas of the United States. For example, the total DDT effects database included toxicity information from Trinity River, Texas (*Daphnia magna*), and Dupage River, Illinois (benthic macroinvertebrates). Overall, 8 of the 21 effects data points used to calculate the ER-L and ER-M values for total DDT were for freshwater organisms. The inclusion of freshwater, or other inappropriate organisms, is a problem for almost all of the chemicals used in the database. Therefore, before any application of the Long and Morgan (1990) database to develop sediment screening values for San Francisco, the appropriateness and applicability of each of the present data sets should be thoroughly evaluated. However, it should be noted that screening of the database will most likely result in a very weak data set for most of the chemicals. Long and Morgan (1990) presently classify the confidence in most ER-L values for organic chemicals as low (see Table 70 in Appendix A). Adequate screening of the data set will further reduce the confidence level.

The Long and Morgan (1990) database also suffers from a bias that results from the inclusion of both derived variables and single toxicity endpoints in the same data set. For example, 13 of the 28 effects data points (46 percent) for pyrene are for derived variables such as screening-level concentrations, AET, and EqP values. In the case of total DDT, 7 of the 21 data endpoints (33 percent) are based on derived variables. Therefore, the data sets contain a highly variable mix of toxicity information, ranging from single toxicity test results to AET that may be based on over 100 individual toxicity tests. Because of the statistical approach used, the resultant screening values are highly biased by individual test results and tend to obscure the large amount of biological information that supports a single AET value.

Examination of the database for pyrene provides an example of the possible bias introduced by combining individual, derived, and theoretical toxicity values into a single data set. The overall effects range for pyrene is 182–1,350,000 ppb, with ER-L and ER-M values of 350 ppb and 2,200 ppb, respectively. Examination of the underlying data set indicates that the only significant effects data below the ER-L are two data points for significant induction of mixed function oxidase (MFO) in winter flounder. This particular endpoint is extremely sensitive to very low levels of contamination, and its ecological relevance is questionable. Moreover, the range of EqP and AET values (the most widely used sediment quality values) is 850–198,000 ppb for pyrene. Long and Morgan (1990), in a subjective assessment of the pyrene data, conclude that an overall AET occurs at about 1,000 ppb. This example illustrates how the approach of Long and Morgan (1990) is highly biased by a few very low toxicity values and tends to disregard the preponderance of toxicity information (calculated by both empirical and theoretical methods) that indicates a much higher threshold level for biological effects.

General Approach Issues

The previous comments have focused on the relevancy of the Long and Morgan (1990) database for the calculation of screening criteria for San Francisco Bay. Although the present database contains many inappropriate values, there are some toxicity data and sediment quality values that may be appropriate for use in the development of screening criteria. However, the most important fundamental issue is whether the general approach used by Long and Morgan (1990) is appropriate for calculation of screening criteria.

Long and Morgan (1990) use an approach that was previously applied to data from spiked-water bioassays by Klapow and Lewis (1979). Their method involves calculating statistical parameters of the distribution of toxicity data showing *significant effects*. The most important concept in this approach is that it is an *effects-only* data summary. No-effects data are excluded from this approach. It is also important to note that Klapow and Lewis (1979) used the technique for single-chemical bioassays, while the Long and Morgan (1990) application was, in most cases, for complex mixtures of chemicals. Although Klapow and Lewis (1979) applied this technique to arrive at meaningful summaries of effects data for individual chemicals, Long and Morgan have applied the technique inappropriately, resulting in ambiguous, and sometimes meaningless, chemical criteria.

In addition to the database problems identified above, there are two main reasons why the general approach specified in the workplan would be inappropriate for use in developing sediment screening criteria:

- The use of effects-only data for chemical mixtures results in the calculation of criteria for individual chemicals that may have *no relationship* to the actual toxicity of those chemicals

- Disregard of the large amount of no-effects data severely weakens the approach because consideration of such results is the only way to develop realistic identification of threshold toxicity levels for chemical mixtures.

The primary limitation of the specified approach is that it is unable to develop any relationship between the concentrations of individual chemicals in a mixture that do not result in a toxic response and those chemicals that are associated with a toxic response. Note that this limitation is *not* that the method does not prove cause and effect. Most approaches to the development of sediment quality values do not prove cause and effect. However, spiked-sediment bioassays performed with individual chemicals, although very time consuming and expensive, can be used to prove cause and effect relationships. The limitation of the Long and Morgan method is that the putative "effects levels" for most chemicals in mixture may actually have no toxic effects whatsoever. The sediment toxicity may be caused by one or more chemicals (measured or unmeasured) that exceed their threshold levels. Therefore, the sample is designated as "toxic," but the only meaningful threshold concentrations are those for the causative chemicals. Concentrations of the remaining chemicals, although entered into the database as "effects levels," may be at concentrations well below actual toxic thresholds.

Examination of the Long and Morgan (1990) database reveals that this fundamental problem with the approach is evident for most of the chemicals, including the metals, upon which the authors place a high degree of confidence. Several examples from the approach illustrate the magnitude of this problem. For mercury, Long and Morgan (1990) calculate ER-L and ER-M values of 0.15 and 1.3 ppm, respectively (see Appendix A for data). The low-end concentrations for the mercury effects database is driven by sample results from various areas, including Waukegan Harbor (IL), Los Angeles Harbor (CA), Lake Union (WA), and Torch Lake (MI). All of these areas had relatively low levels of mercury in the sediments, ranging from 0.08 to 0.29 ppm. Given these results, the basic questions is whether the low levels of mercury measured at the four sites actually caused the toxic responses or whether the toxicity resulted from some other chemical. Examination of the Long and Morgan (1990) data reveals that the four sites were contaminated by many other chemicals that were more likely causing the measured toxic responses. For example, the Lake Union sediments are highly contaminated by PAH compounds, with a pyrene concentration of 750,000 ppb. PCBs at the Lake Union site were measured at 4,300 ppb. Waukegan Harbor had high levels of many organic chemicals, including a PCB concentration of 730 ppb. Only metals were measured at Torch Lake, but copper was found at a concentration of 1,800 ppm.

The data for copper represent a similar situation whereby the effects levels (ER-L of 70 ppm) are dominated by samples with low copper concentrations and high concentrations of other chemicals. For example, the lowest "toxic" levels for copper (15.0 and 19.5 ppm) were measured in Massachusetts Bay and Waukegan Harbor, areas that are contaminated by a variety of organic and inorganic substances.

The disregard of the no-effects data is a primary weakness of the approach. Much of the no-effects data provide direct evidence that the effects results for individual chemicals must have been caused by another chemical. In the case of mercury, 70 percent (28 of 40) of the total data points between the ER-L and ER-M values were classified by Long and Morgan (1990) as "no effect," "no concordance," or "no gradient." Thus, the weight of evidence suggests that the computational results are not valid estimates of effects thresholds and that the actual threshold for mercury, and other chemicals, is substantially higher than the ER-L. For chemicals such as copper, mercury, and PCBs, there are substantial no-effects results at concentrations up to the ER-M values, indicating that the ER-M represents an approximation of the lower effects threshold for those chemicals (i.e., copper = 390 ppm, mercury = 1.3 ppm, and PCBs = 400 ppb). For other chemicals such as nickel and chromium, there are substantial numbers of no-effects results above the calculated ER-M values, indicating that the method does not even provide an approximate estimate of a threshold response level.

APPENDIX A

Selected Tables from Long and Morgan (1990)

Table 70. Summary of ER-L, ER-M, and overall apparent effects thresholds concentrations for selected chemicals in sediment (dry weight).

Chemical Analyte	ER-L Concentration	ER-M Concentration	ER-L:ER-M Ratio	Overall Apparent Effects Threshold	Subjective Degree of Confidence in ER-L/ER-M Values
Trace Elements (ppm)					
Antimony	2	25	12.5	25	Moderate/moderate
Arsenic	33	85	2.6	50	Low/moderate
Cadmium	5	9	1.8	5	High/high
Chromium	80	145	1.8	Nb	Moderate/moderate
Copper	70	390	5.6	300	High/high
Lead	35	110	3.1	300	Moderate/high
Mercury	0.15	1.3	8.7	1	Moderate/high
Nickel	30	50	1.7	NSD*	Moderate/moderate
Silver	1	2.2	2.2	1.7	Moderate/moderate
Tin	NA	NA	NA	NA	NA
Zinc	120	270	2.2	260	High/high
Polychlorinated Biphenyls (ppb)					
Total PCBs	50	400	7.6	370	Moderate/moderate
DDT and Metabolites (ppb)					
DDT	1	7	7	6	Low/low
DDD	2	20	10	NSD	Moderate/low
DDE	2	15	7.5	NSD	Low/low
Total DDT	3	350	117	Nb	Moderate/moderate
Other Pesticides (ppb)					
Lindane	NA	NA	NA	NSD	NA**
Chlordane	0.5	6	12	2	Low/low
Heptachlor	NA	NA	NA	NSD	NA
Dieldrin	0.02	8	400	Nb	Low/low
Aldrin	NA	NA	NA	NSD	NA
Endrin	0.02	45	2250	NSD	Low/low
Mirex	NA	NA	NA	NSD	NA
Polynuclear Aromatic Hydrocarbons (ppb)					
Acenaphthene	150	650	4.3	150	Low/low
Anthracene	85	960	11.3	300	Low/moderate
Benzo(a)anthracene	230	1600	7	550	Low/moderate
Benzo(a)pyrene	400	2500	6.2	700	Moderate/moderate
Benzo(e)pyrene	NA	NA	NA	NSD	NA
Biphenyl	NA	NA	NA	NSD	NA
Chrysene	400	2800	7	900	Moderate/moderate
Dibenz(a,h)anthracene	60	260	4.3	100	Moderate/moderate
2,6-dimethylnaphthylene	NA	NA	NA	NSD	NA
Fluoranthene	600	3600	6	1000	High/high
Fluorene	35	640	18.3	350	Low/low
1-methylnaphthalene	NA	NA	NA	NSD	NA
2-methylnaphthalene	65	670	10.3	300	Low/moderate
1-methylphenanthrene	NA	NA	NA	NSD	NA
Naphthalene	340	2100	6.2	500	Moderate/high
Perylene	NA	NA	NA	NSD	NA
Phenanthrene	225	1380	6.1	260	Moderate/moderate
Pyrene	350	2200	6.3	1000	Moderate/moderate
2,3,5-trimethylnaphthalene	NA	NA	NA	NSD	NA
Total PAH	4000	35000	8.8	22000	Low/low

NSD = not sufficient data
* NA = not available

Table B-5. Sediment effects data available for COPPER arranged in ascending order with remarks regarding use of the concentrations to determine ER-L and ER-M values.

Concentration (ppm)	Biological Test	Remarks
1.02	Georgetown benthic community	No effect
4 ± 3	Mississippi River high toxicity--midge	No concordance
5 ± 2	Massachusetts Bay high species richness	No effect
7.9 ± 5	Mississippi River low toxicity	No effect
8.9 ± 4	Mississippi River low toxicity	No effect
12 ± 6	Southern California high echinoderm abundance	No effect
12.2	Newport low toxicity--shrimp	No effect
13.4 ± 14	Southern California moderate echinoderm abundance	No gradient
15 ± 7	Massachusetts Bay moderate species richness	*
16 ± 7	Massachusetts Bay low species richness	No gradient
17.8	Mississippi River low toxicity	No effect
17.8	ET50 burrowing time bioassay--clam	*
18 ± 15	Trinity River nontoxic--*Daphnia*	No effect
19.5	Waukegan Harbor highly toxic--amphipod	*
19.5 ± 6	Kishwaukee River high number of taxa	Small gradient
23.6	Keweenaw Waterway least toxicity	No effect
27.5 ± 16	Feral Fraser River *Macoma* present	No effect
33	Keweenaw Waterway high number of taxa	No effect
34.5 ± 17	San Francisco Bay least toxic--bivalve	No effect
42.8	Duwamish River nontoxic--shrimp	No effect
43 ± 49	Keweenaw Waterway nontoxic--*Daphnia*	No effect
45.4 ± 53	Kishwaukee River low number of taxa	*
46.9 ± 26	San Francisco Bay not toxic--bivalve	No effect
62.1 ± 25	DuPage River high number of taxa	No effect
62.3 ± 78	Southern California nontoxic--amphipod	No effect
64 ± 40	San Francisco Bay moderately toxic--amphipod	No concordance
67	*Macoma* burrowing bioassay	*
68.2 ± 48	San Francisco Bay significantly toxic--bivalve	*
68.4 ± 62	Trinity River significant toxicity--*Daphnia*	*
70	**ER-L**	**10 percentile**
70 ± 47	San Francisco Bay significantly toxic--amphipod	Small gradient
72.1 ± 41	San Francisco Bay least toxic--amphipod	No effect
72.6 ± 75	Commencement Bay least toxic--oyster	No effect
74.6 ± 43	San Francisco Bay not toxic--amphipod	No effect
76 ± 51	San Francisco Bay moderately toxic--bivalve	*
77.3 ± 39	DuPage River low number of taxa	Small gradient
81	PSDDA screening level	No effect
84.6 ± 63	San Francisco Bay highly toxic--amphipod	*
85.1 ± 69	Commencement Bay least toxic--amphipod	No effect
87.7 ± 33	San Francisco Bay highly toxic--bivalve	*
96.7 ± 177	Southern California low echinoderm abundance	*
98 ± 90	Puget Sound nontoxic--amphipod	No effect
106.3 ± 93	Commencement Bay moderately toxic--oyster	*
110	San Francisco Bay AET--bivalve	*
117.8 ± 98	Commencement Bay moderately toxic--amphipod	*
134.6 ± 57	Feral Fraser River *Macoma* absent	*
135.2 ± 118	Phillips Chain nontoxic--*Daphnia*	No effect
136	EP chronic marine @4% TOC	*
138 ± 124	Puget Sound moderately toxic--amphipod	*
145 ± 2	Sheboygan River toxic--prawn	*
147	Los Angeles Harbor toxic--shrimp	*

Table B-5. (continued)

Concentration (ppm)	Biological Test	Remarks
150	*Macoma* avoidance bioassay	*
156	Lake Union high toxicity–amphipod	*
157.5 ± 29	Baltimore Harbor least toxic–fish	No effect
180	San Francisco Bay AET–amphipod	*
181.3 ± 173	Southern California significant toxicity--amphipod	*
200	Norwegian benthos species diversity	*
210	San Diego Bay nontoxic–various	No effect
216	EP acute marine @4% TOC	*
217.8	Stamford nontoxic–shrimp	No effect
223.7	Norwalk nontoxic–shrimp	No effect
250.5 ± 232	Hudson-Raritan nontoxic–nematode	No effect
251 ± 227	Palos Verdes nontoxic–amphipod	No effect
310	1986 Puget Sound AET–benthic	*
312.3	San Diego Bay nontoxic–mysid	No effect
390	**ER-M**	**50 percentile**
390	1986 Puget Sound AET–oyster	*
390	1986 Puget Sound AET- Microtox™	*
453 ± 311	Hudson-Raritan highly toxic–nematode	*
530	1988 Puget Sound AET–benthic	*
540	Phillips Chain significant toxicity–*Daphnia*	*
589	Keweenaw Waterway least number of taxa	*
591.7 ± 126	Palos Verdes major benthic degradation	*
591.7 ± 126	Palos Verdes significant toxicity–amphipod	*
612	Black Rock Harbor highly toxic	*
612	Keweenaw Waterway highly toxic–*Daphnia*	*
681	LC50 *Daphnia* spiked bioassay–Soap Creek	*
730	Keweenaw Waterway significant toxicity–*Daphnia*	*
810	1986 Puget Sound AET–amphipod	*
857	LC50 midge spiked bioassay–Soap Creek	*
917.8 ± 2750	Commencement Bay highly toxic–oyster	*
937	LC50 *Daphnia* spiked bioassay–Tualatin River	*
964	LC50 amphipod spiked bioassay- Soap Creek	*
995	San Diego Bay nontoxic–clam	No effect
995	San Diego Bay nontoxic–polychaete	No effect
1071 ± 948	Baltimore Harbor most toxic-fish	*
1078	LC50 amphipod spiked bioassay–Soap Creek	*
1260 ± 3251	Puget Sound highly toxic–amphipod	*
1300	1988 Puget Sound AET–amphipod	*
1374 ± 809	Little Grizzly Creek toxic–*Daphnia*	*
1800	Torch Lake highly toxic–*Daphnia*	*
2296	LC50 midge spiked bioassay–Tualatin River	*
2820 ± 4881	Commencement Bay highly toxic–amphipod	*

* 51 concentrations used to determine ER-L and ER-M values

Table B-7. Sediment effects data available for MERCURY arranged in ascending order with remarks regarding use of the concentrations to determine ER-L and ER-M values.

Concentration (ppm)	Biological Test	Remarks
0.026	Newport not toxic–shrimp	No effect
0.032	EP chronic marine @4% TOC	*
0.035	Mississippi River low toxicity	No effect
0.05	Duwamish River not toxic–shrimp	No effect
0.06	Massachusetts Bay high benthos species richness	No effect
0.08	Waukegan Harbor highly toxic–*Hyalella*	*
0.08 ± 0.1	Kishwaukee River high number of taxa	No effect
0.09 ± 0.1	Kishwaukee River low number of taxa	No gradient
<0.1	Sheboygan River significant toxicity–prawn	Below detection
0.1 ± 0.1	Feral Fraser River *Macoma* present	No effect
0.11 ± 0.02	Massachusetts Bay low benthos species richness	No gradient
0.13 ± 0.1	Keweenaw Waterway not toxic–*Daphnia*	No effect
0.13	Keweenaw Waterway least toxic–*Daphnia*	No effect
0.147	Los Angeles toxic (>50% mortality)–shrimp	*
0.15	**ER-L**	**10 percentile**
0.162	Stamford not toxic–shrimp	No effect
0.173	Lake Union 95% mortality–amphipod	*
0.18 ± 0.1	Massachusetts. Bay moderate benthos species richness	No gradient
0.18	*Macoma* burrowing time bioassay	*
0.18	Keweenaw Waterway most toxic–*Daphnia*	No gradient
0.2 ± 0.1	Commencement Bay least toxic–amphipod	No effect
0.2 ± 0.1	Commencement Bay moderately toxic–oyster	No gradient
0.2 ± 0.1	Commencement Bay least toxic–oyster	No effect
0.2 ± 0.1	Keweenaw Waterway significantly toxic–*Daphnia*	No gradient
0.21	PSDDA screening level	No effect
0.28 ± 0.2	DuPage River high number of taxa	No effect
0.29	Torch Lake significant mortality–*Daphnia*	*
0.3 ± 0.2	Commencement Bay moderately toxic–amphipod	No gradient
0.3 ± 0.2	San Francisco Bay least toxic–bivalve	No effect
0.3 ± 0.1	Trinity River significantly toxic–*Daphnia*	No concordance
0.3	Norwalk not toxic–shrimp	No effect
0.33 ± 0.1	Southern California significantly toxic–amphipod	No gradient
0.34 ± 0.02	Southern California not toxic–amphipod	No effect
0.38 ± 0.1	Baltimore Harbor least toxic–fish	No effect
0.41	1986 Puget Sound AET–Microtox™	*
0.42 ± 0.2	Feral Fraser River *Macoma* absent	*
0.47 ± 0.5	Puget Sound nontoxic–amphipod	No effect
0.48	*Macoma* avoidance bioassay	*
0.5 ± 0.4	San Francisco Bay least toxic–amphipod	No effect
0.5 ± 0.3	San Francisco Bay not toxic–bivalve	No effect
0.59	1986 Puget Sound AET–oyster	*
0.6 ± 0.4	San Francisco Bay not toxic–amphipod	No effect
0.6 ± 0.4	San Francisco Bay highly toxic–bivalve	No concordance
0.6 ± 0.7	Trinity River low toxicity–*Daphnia*	No effect
0.6	EP acute marine @4% TOC	*
0.61	Georgetown benthic community	No effect
0.65-1.15	*Pontoporeia* activity not significantly decreased	No effect
0.7 ± 0.8	San Francisco Bay moderately toxic–amphipod	No gradient
0.7 ± 0.8	San Francisco Bay significantly toxic–amphipod	No gradient}
0.7 ± 0.9	San Francisco Bay significantly toxic–bivalve	No gradient
0.88	1986 Puget Sound AET–benthic	*

Table B-7. (continued)

Concentration (ppm)	Biological Test	Remarks
0.9 ± 1	San Francisco Bay moderately toxic–bivalve	*
0.9	Cubatao River EC50 toxicity–*Daphnia*	*
0.96 ± 1	San Francisco Bay highly toxic–amphipod	*
1.02 ± 1.3	Phillips Chain not toxic–*Daphnia*	No effect
1.3	ER-M	50 percentile
1.3	San Francisco Bay AET-amphipod	*
1.38 ± 4.6	Puget Sound intermediate toxicity–amphipod	*
1.5	San Francisco Bay AET–bivalve	*
1.5 ± 0.9	L. Grizzly Creek significantly toxic–*Daphnia*	*
1.6 ± 1.1	Baltimore Harbor most toxic–fish	*
1.6 ± 2	DuPage River low number of taxa	*
2.1	1986 Puget Sound AET–amphipod	*
2.1	1988 Puget Sound AET–benthic	*
2.15-3.35	*Pontoporeia* activity sign decreased	*
2.7	San Diego Bay not toxic–various	No effect
3.5 ± 12.5	Commencement Bay highly toxic–oyster	*
5 ± 6.7	Hudson-Raritan not toxic–nematode	No effect
5.04 ± 14.8	Puget Sound highly toxic	*
8.9 ± 7.5	Hudson-Raritan highly toxic–nematode	*
9.4	Phillips Chain significantly toxic	*
11.2 ± 22.8	Commencement Bay highly toxic–amphipod	*
13.1	LC50 amphipod bioassay	*
34.9	New York nontoxic, 100-d, various species	No effect
58.2	San Diego Bay not toxic–mysid	No effect
66.5	San Diego Bay not toxic–clam	No effect
254.4	San Diego Bay not toxic–fish	No effect

* 30 concentrations used to determine ER-L and ER-M values

Table B-15. Sediment effects data available for total DDT arranged in ascending order with remarks regarding use of the concentrations to determine ER-L and ER-M values.

Concentration (ppb)	Biological Test	Remarks
1.58	EP saltwater chronic, assuming 1% TOC	*
1.9	Freshwater SLC, assuming 1% TOC	*
3	**ER-L**	**10 percentile**
3.29	EP saltwater chronic, assuming 1% TOC	*
6.9	PSDDA screening level	No effect
6.9 ± 9.8	Trinity River low mortality–*Daphnia*	No effect
8.28	Interim EP saltwater criteria, assuming 1% TOC	*
19.6 ± 18.4	DuPage River highest taxa richness	No effect
20	Lethal threshold-*Crangon* bioassay	*
28.6 ± 36.1	Southern California not toxic–amphipod (excludes Palos Verdes sample)	No effect
31	97-h LC50 *Crangon* spiked bioassay	*
31.4 ± 20.4	Trinity River significant mortality–*Daphnia*	*
45.9	Calculated EP threshold for freshwater	*
50 ± 60	Southern California high echinoderm abundance	No effect
68 ± 71.7	Southern California significantly toxic--amphipod	No concordance
90 ± 130	Southern California moderate echinoderm abundance	*
100 ± 150	Southern California high arthropod abundance	No effect
210 ± 490	Southern California moderate total abundance	No concordance
221.7 ± 281.6	DuPage River least taxa richness	*
250 ± 620	Southern California moderate species richness	No concordance
350	**ER-M**	**50 percentile**
350 ± 710	Southern California moderate arthropod abundance	*
428	Saltwater SLC, assuming 1% TOC	*
505	Saltwater SLC, assuming 1% TOC	*
1018.2 ± 2424	Southern California not toxic-amphipod (includes Palos Verdes sample)	No effect
1410 ± 5440	Southern California low total abundance	No concordance
2170 ± 7190	Southern California high species richness	No effect
4950	Overall LC50 for *Rhepoxynius* bioassay	*
11000	LC50 *H. azteca* bioassay @ 3% TOC	*
13420 ± 37670	Southern California low arthropod abundance	*
14190 ± 40200	Southern California low species richness	*
16500	No deaths *N. virens* spiked bioassay	No effect
18260 ± 43080	Southern California low echinoderm abundance	*
19600	LC50 *H. azteca* bioassay @ 7.2% TOC	*
35300 ± 59540	Southern California high total abundance	No effect
49700	LC50 *H. azteca* bioassay @ 10.5% TOC	*
67232	LD50 cricket nymph bioassay	*

* 21 concentrations used to determine ER-L and ER-M values

Table B-30. Sediment effects data available for PYRENE arranged in ascending order with remarks regarding use of the concentrations to determine ER-L and ER-M values.

Concentrations (ppb)	Biological Test	Remarks
182	Kidney MFO induction–winter flounder	*
184 ± 318	Southern California not toxic–amphipod	No effect
216 ± 102	San Francisco Bay least toxic–bivalve	No effect
300	Liver MFO induction–winter flounder	*
350	Eagle Harbor predicted LC50–amphipod	*
350	**ER-L**	**10 percentile**
360	Liver somatic condition–winter flounder	*
430	PSDDA screening level	No effect
434 ± 442	Commencement Bay least toxic–oyster	No effect
434	Marine SLC @1% TOC	*
532 ± 372	Southern California significantly toxic–amphipod	*
665	Marine SLC @1% TOC	*
701 ± 866	San Francisco Bay least toxic–amphipod	No effect
719 ± 1123	San Francisco Bay not toxic–bivalve	No effect
724 ± 939	San Francisco Bay moderately toxic–bivalve	*
743 ± 902	San Francisco Bay not toxic–amphipod	No effect
777 ± 908	San Francisco Bay highly toxic–amphipod	Small gradient
806 ± 975	San Francisco Bay significantly toxic–bivalve	Small gradient
850	EP 99 percentile chronic marine @ 1% TOC	*
865 ± 719	Commencement Bay moderately toxic–amphipod	No concordance
896 ± 870	San Francisco Bay significantly toxic–amphipod	Small gradient
978 ± 996	Commencement Bay least toxic–amphipod	No effect
1078 ± 806	Commencement Bay moderately toxic–oyster	*
1110 ± 904	San Francisco Bay moderately toxic–amphipod	*
1538 ± 1501	Commencement Bay highly toxic–oyster	*
1820 ± 2252	Commencement Bay highly toxic–amphipod	*
1900	EP 95 percentile chronic marine @ 1% TOC	*
2188 ± 776	San Francisco Bay highly toxic–bivalve	*
2200	**ER-M**	**50 percentile**
2500	Columbia River bioassays–amphipod	No effect
2600	1986 Puget Sound AET–Microtox™	*
2600	San Francisco Bay AET–amphipod	*
3300	1986 Puget Sound AET–oyster	*
>3400	San Francisco Bay AET–bivalve	Not definitive
4300	1986 Puget Sound AET–amphipod	*
>7300	1986 Puget Sound AET–benthic	No definitive value
13100	EP interim freshwater criteria @ 1% TOC	*
16000	1988 Puget Sound AET–amphipod	*
16000	1988 Puget Sound AET–benthic	*
33750	LC50 2.5% Elizabeth River–spot	*
49500	EP acute safe level	*
198000	EP chronic marine @ 4% TOC	*
750000	Lake Union significantly toxic–amphipod	*
756000	LC50 56% Elizabeth River–spot	*
1350000	LC100 100% Elizabeth River–spot	*

*28 concentrations used to determine ER-L and ER-M values.

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19 September 1993

Thomas H. Wakeman, III
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Dear Tom,

Following are some comments on the documents provided to the committee at our last meeting. Also included are comments and copies of correspondence on related issues.

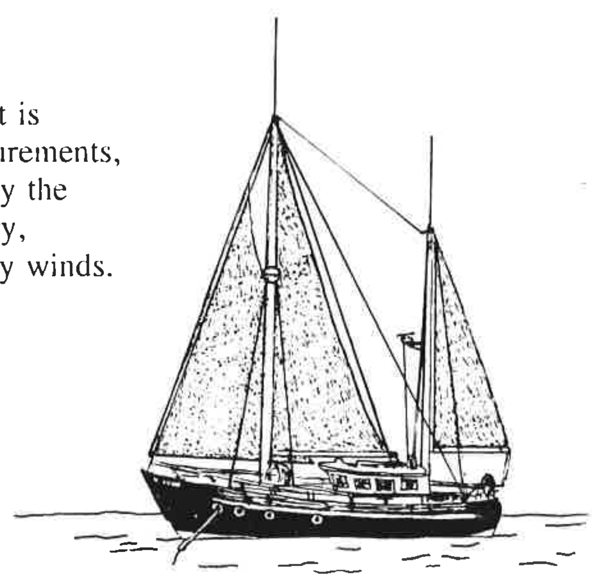
Kagan, The Dredging Dilemma.

This document provides a good summary of the diverse obstacles to any kind of decision about dredging in Oakland Harbor. Going on from that, an issue that now seems to be relevant is how credibility on the environmental issues might be increased among all concerned parties. With respect to contaminants, there is now an obvious approach. The present programs in San Francisco Bay are generating a large data base on the distribution of all contaminants of current concern in sediments, the water column, and the biota of San Francisco Bay. The amounts of most contaminants can now be related to effect levels. This should now be done, followed by a thorough review by independent scientists. A number of contaminants on the lists just are not found, or are present in extremely low levels. These need to be "delisted". Almost all documents list the PCBs as hazards. Just where are current levels in comparison with those of demonstrated harm? How do the total amounts released in a dredge spoil operation compare with those in the ambient water column? Enough to cause a temporary increase of 1%, 10%, 100%, 1000 %? A mass balance approach is clearly needed.

A series of documents addressed to the public on these several issues would appear to be useful.

Factors Affecting San Francisco Bay Sedimentation Processes

This document proposes a very wide variety of studies but it is not evident that all would be of value. The most important measurements, - of incoming sediment loads, are presumably being continued by the USGS. Next is priority would appear to be updating, if necessary, the estimates of Krone of resuspension of sediments in the Bay by winds.



Since two of the principal concerns about the effects of dredging, -suspended sediment effects on herring, and depression of fishing success with increasing turbidities, come from an increase in the water column of suspended sediments, more data, or a review of available data, on changes in suspended sediment loads following dredge spoil operations would appear to be valuable.

Most of the proposed studies appear to be of lesser relevance, but I could be convinced otherwise.

Proposal for a Simplified Laboratory Test ....

It seems to me that this project is going in the wrong direction. Runoff will depend on local variabilities - amount of erosion, amount and intensity of rainfall, etc., such that laboratory experiments could hardly predict what it will be. The volume of receiving waters is another important parameter. Instead, to predict what will be in the runoff it could be sufficient to estimate the volume of erosion and to determine the concentrations of contaminants of concern in the sediments. Once these are saturated with water, concentrations in the water phase can be estimated from partition coefficients. Another estimate/assumption that must be made would be the proportion of waters in the sediments that will be displaced with additional rainfall. The result, to be verified with field sampling and laboratory measurements, would be water concentrations that may or may not exceed water quality criteria. In many environments, salinity would be of initial concern.

Summary Progress Report, Regional Monitoring Program 1991-1992

In that the data set was incomplete (for which a major part of the responsibility is mine), a thorough review of the results of the program would be premature at this time. Current projects of the Regional Board that are attempting to pinpoint the causes of the measured toxicities are clearly on the right track. At the present time, protection policies based on observed toxicities lack a firm and defensible foundation.

At least one of the aims of the program, - to generate Apparent Effects Threshold values for San Francisco Bay, needs to be reviewed critically.

Related issues

1. Dredging at the Exxon Refinery in Benicia; correspondence from the agencies in late 1992

A discussion of some of the points raised by the several agencies might lead to a clarification of the relevant issues.

Department of Fish and Game, letter of J.L. Turner of 5 October 1992. "Grain-size evaluation of project sediments showed approximately equal parts of sand, silt and clay, whereas the Carquinez Strait reference site tested to be slightly more than 94 percent sand". A high sand content indicates that prevailing currents in the area remove finer sediment particles. Silt and clay particles deposited at the site would therefore be carried elsewhere, just as are the silt and clay particles that constitute the major portion of suspended sediments entering the Bay in the rivers. "Bulk chemistry analysis of dredge sediments indicated elevated levels, generally within one order of magnitude, for heavy metals, organotins, and some PAHs over reference". Concentrations of these contaminants are always lower in sand, such that this comparison is hardly valid. Through association with finer material most of these contaminants would not stay at the disposal site. Of much greater relevance is whether or not the measured levels are legitimate causes for concern; how they compare to those elsewhere in the Bay is a much more important consideration. These statements should not therefore have been used to support the conclusion "The DFG views these sediments as only marginally acceptable for unconfined aquatic disposal ... ".

Fish and Wildlife Service, letter of 15 October 1992 of Wayne S. White. "The Service has consistently maintained that prolonged and often continuous dumping of dredged material within the Bay makes a significant contribution to reduced water quality and the observed decline of biotic resources". The suspicion emerges that this position might not be based on either empirical data or a well-founded basis for concern. Which are the data on water quality and what specifically are the cases of biological degradation? A clarification of these points would surely lead to a sounder basis for making decisions.

EPA, letter of Harry Seraydarian of 15 October 1992. "The test results show potential toxicity of the dredged material ... We are therefore unable to determine from the existing data whether disposal of the material tested would result in unacceptable adverse impacts to the aquatic ecosystem". Even with demonstrated toxicity the conclusion does not follow that there would be "unacceptable adverse impacts". Since the dispersal of sediments by human and natural activities has been going on for a long time, just what have been these adverse impacts?

There is an evident need for clearer definitions of the issues.

3. Letter of John L. Turner to Mr. Mike Kahoe, Response to Letter from the Bay Planning Coalition

There are a number of additional examples in this letter of issues that also deserve consideration. Attached is a copy of a private letter to Mr. Turner in which several questions are posed.

Sincerely,

Robert W. Risebrough

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20 September 1993

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John L. Turner, Acting Chief
Environmental Services Division
Department of Fish and Game
1416 Ninth Street
Sacramento, CA 95814

Dear Mr. Turner,

I have been compiling all available evidence for deleterious effects on the biota of San Francisco Bay that are associated with contaminants or that result from activities such as dredging. In your letter of March 16, 1992, to Mr. Mike Kahoe, California Environmental Protection Agency, your Response to Letter from the Bay Planning Coalition, you raise a number of issues that deserve critical scrutiny. With the intent to clarify these as far as is possible, kindly permit me to pose several questions.

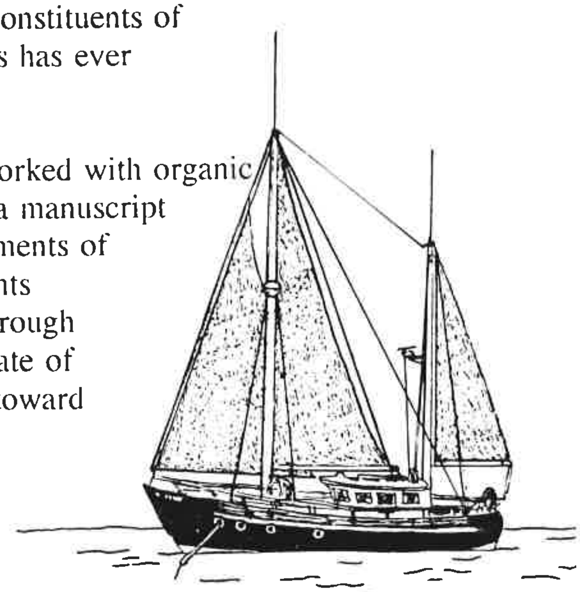
In this memorandum, which "outlines the scientific basis for the Department's recommendations", you state that "Dredging and dredge disposal activities can harm fish and wildlife in a variety of ways". Yet none of the deleterious effects you mention can be linked with dredging at any level of scientific certainty. Should this statement not be considered then as a working assumption rather than as a scientific fact?

Among your concerns you list:

- "Loss of benthic habitat ..." With very few disposal sites, and since the volume of dredged material that is dispersed is small when compared to the total that enters the system every year in the rivers and that is resuspended by winds, can this still be considered a significant impact?

- "Acute toxicity to fish and other aquatic organisms, and loss of dissolved oxygen in the water, due to sulfides, heavy metals, organics, and other constituents of dredge materials". I know of no instance when anything like this has ever occurred. Can you refer me to your source(s)?

- "Exposure to bioaccumulating substances" Although I have worked with organic contaminants for almost 30 years, and am currently working on a manuscript about the input of contaminants into the water column from sediments of the Palos Verdes Peninsula, I know of no reference that documents increases in accumulation as a result of sediment resuspension through dredging in areas like San Francisco Bay where there is a high rate of natural resuspension by winds. Again, any help in pointing me toward any relevant reference would be appreciated.



- "Impacts of suspended solids on herring spawn". The spawning season largely overlaps the storm season such that the herring are exposed to the suspended sediments brought in to the Bay by the flooding rivers. The total amount of suspended solids entering the Bay from these sources may vary from year to year by a factor of 20 or more, depending on the volume of water from runoff. In very wet years the amount of suspended sediments brought in by the rivers greatly exceeds the volume moved by dredging. If suspended solids had a significant effect on the herring, would not productivity be depressed in years of high sediment loadings? If a significant relationship were found, the hypothesis that suspended sediments from dredging have, or could have, a deleterious effect would be strengthened.

- "Increases in water turbidity, with resulting impacts on marine life and fishing". Would it be possible to undertake a statistical analysis of the secchi disk data? From a comparison of means between 1980 - 1985 and 1986-1988 it is not possible to conclude that the difference is significant. You mention a "dramatic decline (66%) in reported fish catch .. 1986 through 1988". But the numbers of total anglers and of boat days also were lower; those for 1988 are less than 1/6 of those in 1983-1984. Should this analysis not be re-done (and brought up to date)? The stronger the data set, the sounder will be the decisions based on it.

Discussion of these issues on a technical level among all concerned and interested parties could be useful, the aim being to provide for the same level of rigorous protection of fish and wildlife that your Department has continued to support, but at a lower cost to society. Everyone, and not just the city of Oakland, has been paying for the long time it takes to make and implement environmentally sound decisions.

Sincerely yours,

Robert W. Risebrough

cc: Technical Review Panel, LTMS
Bay Planning Coalition

CEWES-EP-D 16 March 1993

MEMORANDUM FOR RECORD

SUBJECT: Meeting Report - Technical Review Workshop of the CESPN Long-Term Management Strategy (LTMS), 19 February 1993

1. I attended the subject meeting (encl 1) as technical advisor on LTMS to CESPN. Experts attending the review were: Drs. Don F. Boesch, Robert Risebrough, and Tom Ginn. Drs. H. Shen and David Stoddard were absent. The meeting was chaired by Mr. Tom Wakeman (PM/LTMS) and followed the enclosed agenda. Presentations were made by Mr. Wakeman and representatives of other agencies regarding their program assignments. Mr. Wakeman opened the meeting with a brief progress report and distributed review documents on environmental windows, sedimentation studies, dredging policy review and a regional monitoring program and asked the participants to comment as appropriate.

2. Mr. Wakeman reviewed the results of a recent meeting of the LTMS Management Committee and summarized their views on the future or the vision for dredged material activities (encl 2). Low, medium and high risk approaches were discussed (encl 2), and it was noted that the high risk approach was chosen. This will call for a major shift in some Bay area agencies' policies towards dredged material management if their vision is to be realized.

3. Mr. Ota, EPA, reviewed the status of the draft ocean site designation EIS and noted that it was on schedule for a 1994 designation. Comments received to date were related to data interpretation, concern with monitoring plan, safety and shipping issues, marine sanctuary abatement concerns, the lack of in-bay disposal sites, and funding questions related to monitoring costs (who pays?). It was agreed by all that the site designation was welcome.

4. Discussion on land based sites, or the lack thereof, was concerned with to inability of meeting goal of having upland sites available when and in-bay alternatives were fully operational. It was suggested to simply let the "market place" determine the need and siting of necessary land sites for material unsuitable for in-bay and ocean placement, and that a dredged material disposal alternatives "road map" was needed for the regulated community and regulatory agencies. It was agreed that the "road map" would at least place all concerned at the same level of general understanding. It was pointed out that agencies must clearly discriminate between wetlands enhancement and upland disposal as some confusion seems to exist, although I cannot understand why. Current cost estimates for land disposal and rehandling seem competitive in comparison to other parts of the nation.

5. An adjunct discussion was held regarding sediment quality criteria, guidelines, or screens, and Dr. Ginn noted that the scientific underpinning of various approaches must be carefully evaluated before an approach is selected. It was noted that the "Long and Morgan" approach had fundamental technical deficiencies and should not be used in any aspect of a screen or criteria.

6. Mr. Carlin of the Regional Water Quality Control Board (RWQCB) initiated the discussion of progress of the in-bay portion of the LTMS. Prior to this review, he noted that the RWQCB had to carefully interface science and policy in their ultimate decision making. Sediment screening criteria were briefly described with a discussion of pros and cons. It was noted that the type of interactions among the RWQCB, EPA, and the Corps may require future changes in oversite. The Regional Monitoring Program (RMP) was described as phased linked to other programs (LTMS?) examines cause and effect and documents accountability to the public and program sponsors. It was noted that the National Academy of Sciences "Managing Troubled Waters" was used in the conceptual design of the RMP.

7. Additional in-bay discussions noted the sediment quality work that is producing the Standard Methods Manual, uniform data format, improved sediment toxicity tests, ammonia toxicity studies and sediment monitoring. Environmental effects work in the in-bay area include: bioaccumulation, suspended sediments effects, and field monitoring. Dr. Boesch pointed out that suspended sediments effects, even though studied in many places, should be resolved in relation to seasonal restrictions and in relation to toxics in dredged material. He had a much greater concern for physical habitat modification than for the contaminants. Dr. Boesch further noted that the answer to dredged material management questions is in an understanding of the relative risks associated with the various components of the dredging process and disposal alternatives. As such, it was important to link dredging to overall sediment movement in the bay and then associate the risk of that impact with the others in the bay.

8. General Discussion. Dr. Boesch opened discussion with a question of what was in the realm of future possibilities? 1) there will be an ocean site, 2) a definitive upland disposal strategy will make a difference in mobilizing support for this alternative but the technical questions have not been answered, 3) habitat enhancement should be actively pursued, 4) in-bay disposal will continue but in only measured amounts of Alcatraz at today's level or maybe less. Dr. Boesch noted that

environmental issues are primarily local and as such a bay wide model was probably not needed and that efforts be focused on the risk to those local sites. He was also concerned with the metalsresearch and that trace metal levels may be best be set at some arbitrary level. It was noted that sediment budget questions may best be resolved by box models rather than elaborate models and that perhaps empirical models may be a better use of funds. Dr. Boesch summarized by stating we need to manage for risk minimization through use of; 1) better biological indicators of potential impact, 2) improved ability in applying biological tests, and 3) to focus on near term goals while continuing some (presumably lower) level of long term work to help address future problems.

9. Dr. Ginn's summary remarks noted that; 1) he was not sure where the sediment transport and hydrodynamic work was going and was concerned with these efforts, 2) there was a need to monitor and have good tools to accomplish that task, 3) it is necessary to measure the performance of various bioassays, 4) it is necessary to determine which tools are appropriate to use, 5) the pore water tests have serious problems and are of little use, 6) some of the LTMS and associated work was very fundamental research and may not be helpful in solving immediate problems, and 7) the program stress collecting the same species for impact assessment work. Dr. Risebrough noted that modeling efforts were important regarding resuspension and redistribution of sediments and for evaluating chemical fingerprints.

10. The meeting was generally successful, but somewhat disorganized due to the lack of attendance by certain LTMS participants and agenda changes. It appears that a haphazardous or inconsistent reallocation of funds to "high" priority items over the remaining life of the LTMS program may result if careful consideration is not given to all review comments in light of the overall objective of LTMS and the vision statements in enclosure 2. The next meeting is scheduled for September 1993 and will emphasize nonaquatic alternatives. It is most important at this time in the program that a thorough evaluation of non-aquatic alternatives be initiated and critical decisions made as to how this part of LTMS will be wrapped up.

2 Encls

ROBERT M. ENGLER, PhD
Manager, Environmental Effects
of Dredging Programs

CF:
Tom Wakeman, CESPN-PM-C